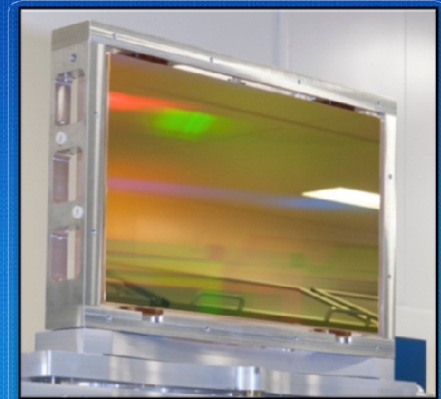
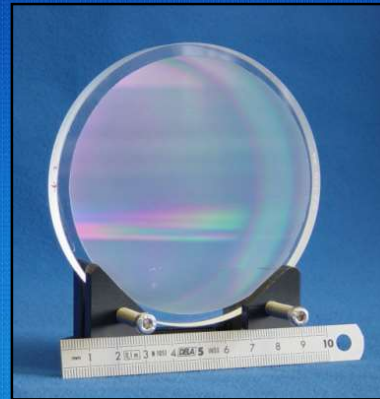
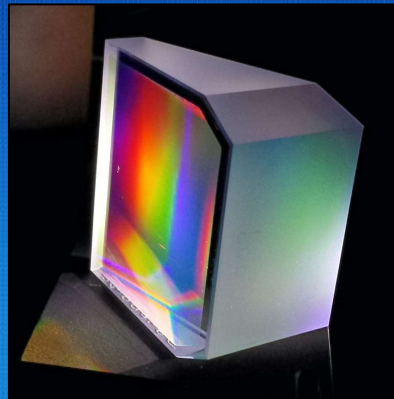
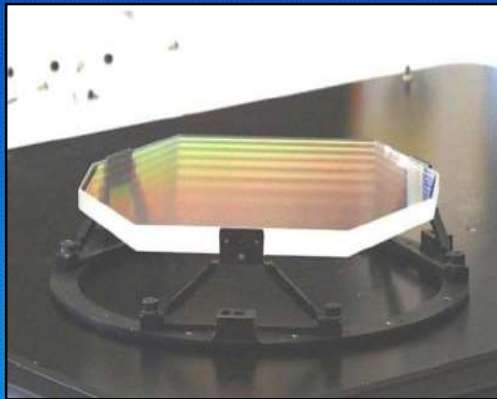


HORIBA

Explore the future



HORIBA

Components division

9th October 2017

Christophe GOMBAUD

Large Size and High Performances Diffraction Gratings for Astronomy Applications

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Explore the future

Automotive Test Systems | Process & Environmental | Medical | Semiconductor | Scientific

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OUTLINE

- **HORIBA Jobin Yvon company overview and Gratings Capabilities**
- Ruled blazed gratings in reflection and transmission
- Transmission Fused Silica Etched (FSE) Holographic Gratings / Grisms

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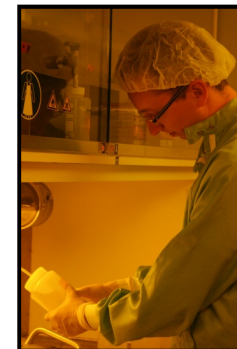
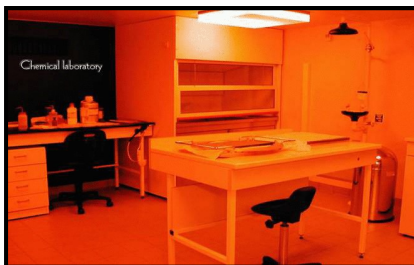
HORIBA Jobin Yvon Overview

- **Founded in 1819 in Paris by M. Jobin and Yvon (Fresnel)**
- **Acquired by HORIBA in 1997**
- **HORIBA France SAS : 350 employees**
HORIBA global group: 7000 employees
- **2 Gratings production sites :**
 - **Longjumeau (France)**
 - **Palaiseau (France)**



Longjumeau Grating Facility

- **Historical Jobin Yvon Gratings facility.**
- **Holographic recording setups up to 600mm in clean room to produce Master Gratings.**
- **State-of-the-art Ruling Machine for ruled blazed grating**
- **Metrology : efficiency, interferometer, AFM, groove density, ...**



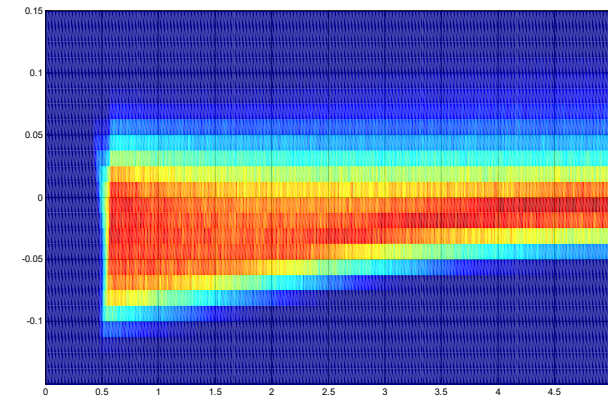
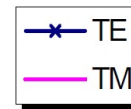
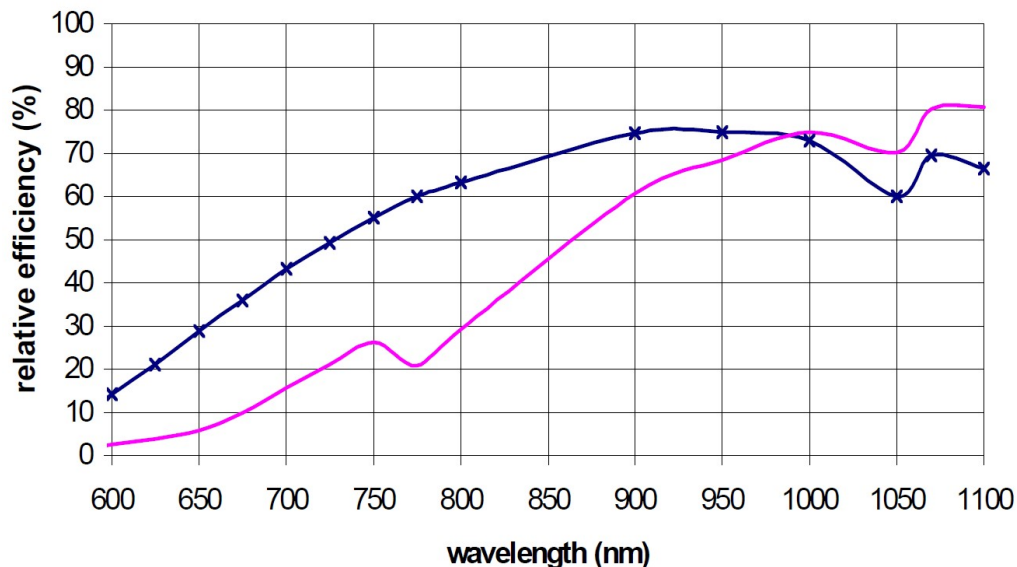
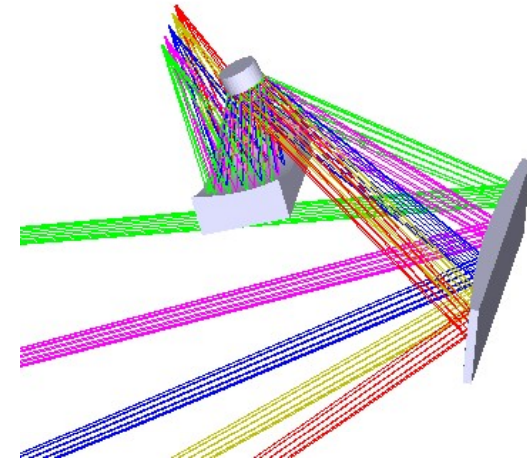
NEW Palaiseau Grating Facility

- **Built in 2012 as the HORIBA Scientific R&D center in Europe.**
- **Holographic recording setup up to 1500mm in clean room to produce Master Gratings.**
- **Replica Gratings production.**
- **Metrology : efficiency, visual inspection, AFM, 32” interferometer**



A whole R&D team dedicated to your project

- **Ray tracing (Grating – Complete system)**
- **Recording parameters optimization**
- **Optical layout optimization**
- **Grating efficiency calculation**



OUTLINE

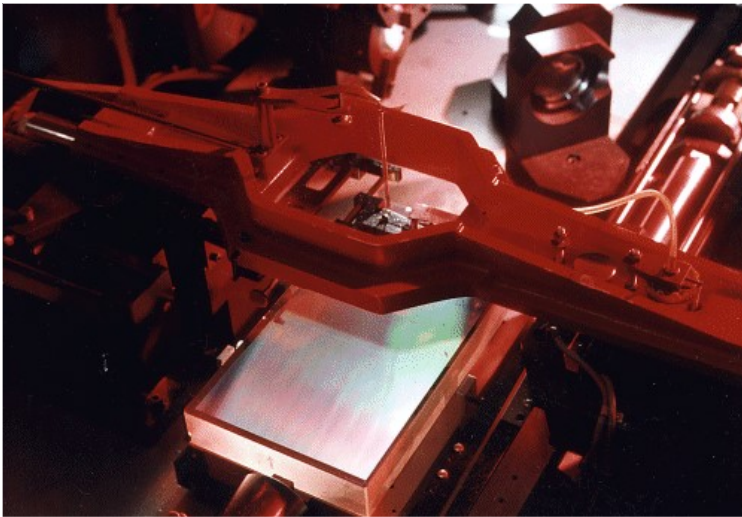
- HORIBA Jobin Yvon company overview and Gratings Capabilities
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- **Transmission Fused Silica Etched (FSE) Holographic Gratings / Grisms**



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Ruling machine for Blazed gratings

Diamond ruling :



Diamond element directly engraves the groove profile which is blazed.

KEY FEATURES :

- Dedicated to **low groove density**
- **Very high efficiency in IR**
- **Ghost-free and low stray light**
- Compatible with Echelle grating type manufacturing
- **Replication possible (TRL9)**
- **Various substrate material : SiC, Metal, Glass**

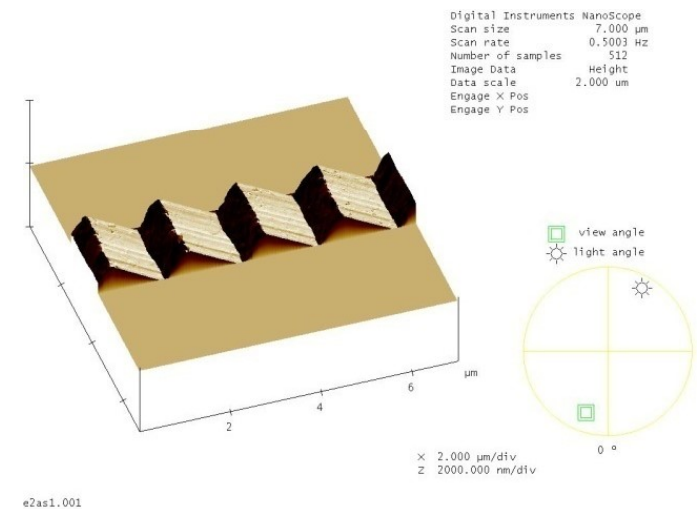
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Ruled blazed low groove density plane reflection grating

Space mission for Jupiter : Grating for a high resolution spectrometer for Jupiter atmosphere and spectral properties in the Mid-IR (2-5 μ m).

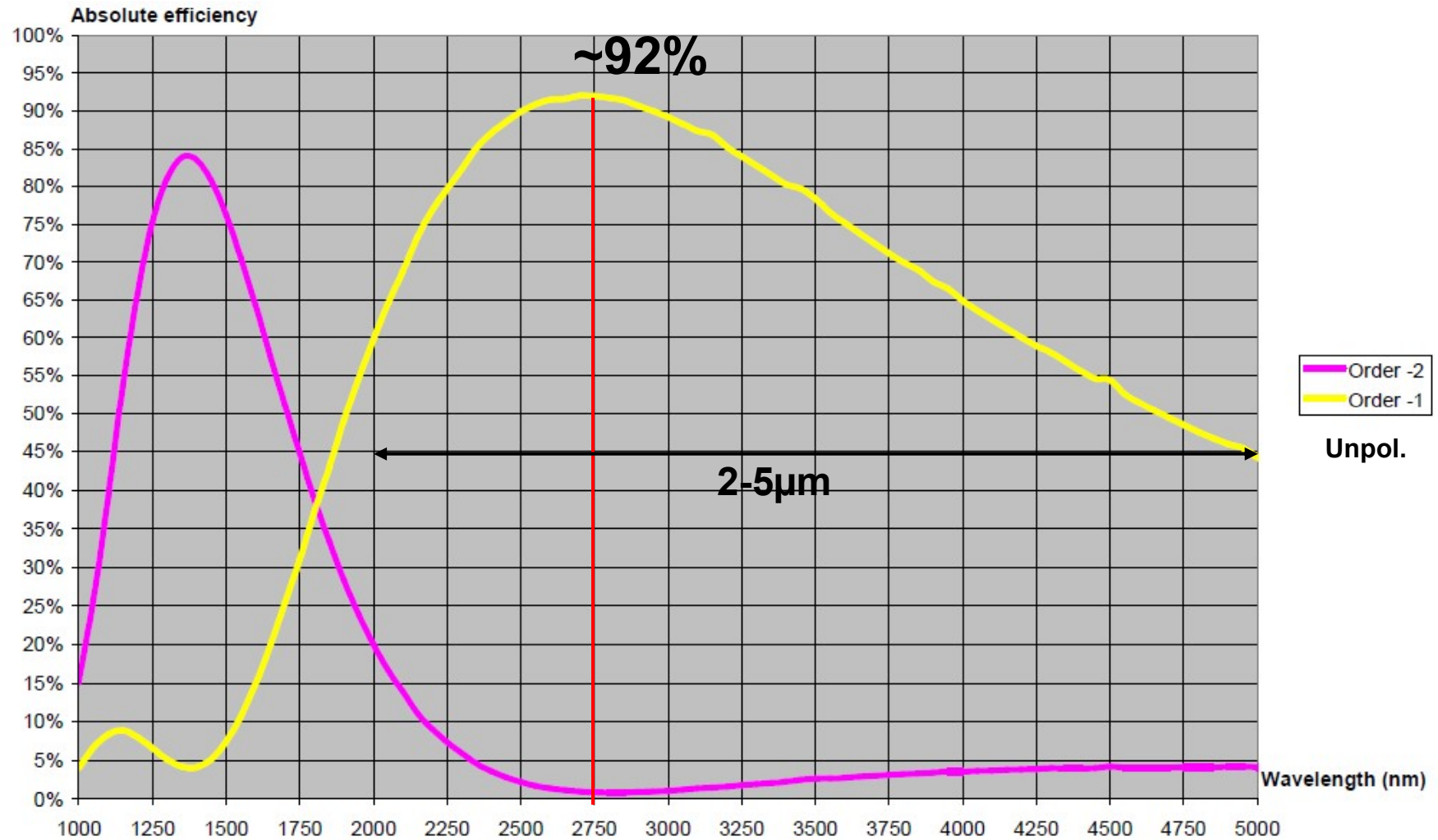
- **Low blazed angle master ruled gratings ;**
- Spectral range : Mid-IR 2-5 μ m ;
- Groove density : **30gr/mm** ;
- Dimensions : 60x32mm ;
- Plane shape ;
- Space flight environmental conditions qualified (thermal cycling from -173°C to +70°C).



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Ruled blazed low groove density plane reflection grating



ESA-JAXA Bepi Colombo Mercury mission – VIHI instrument (Selex ES) (2011 - 2012)

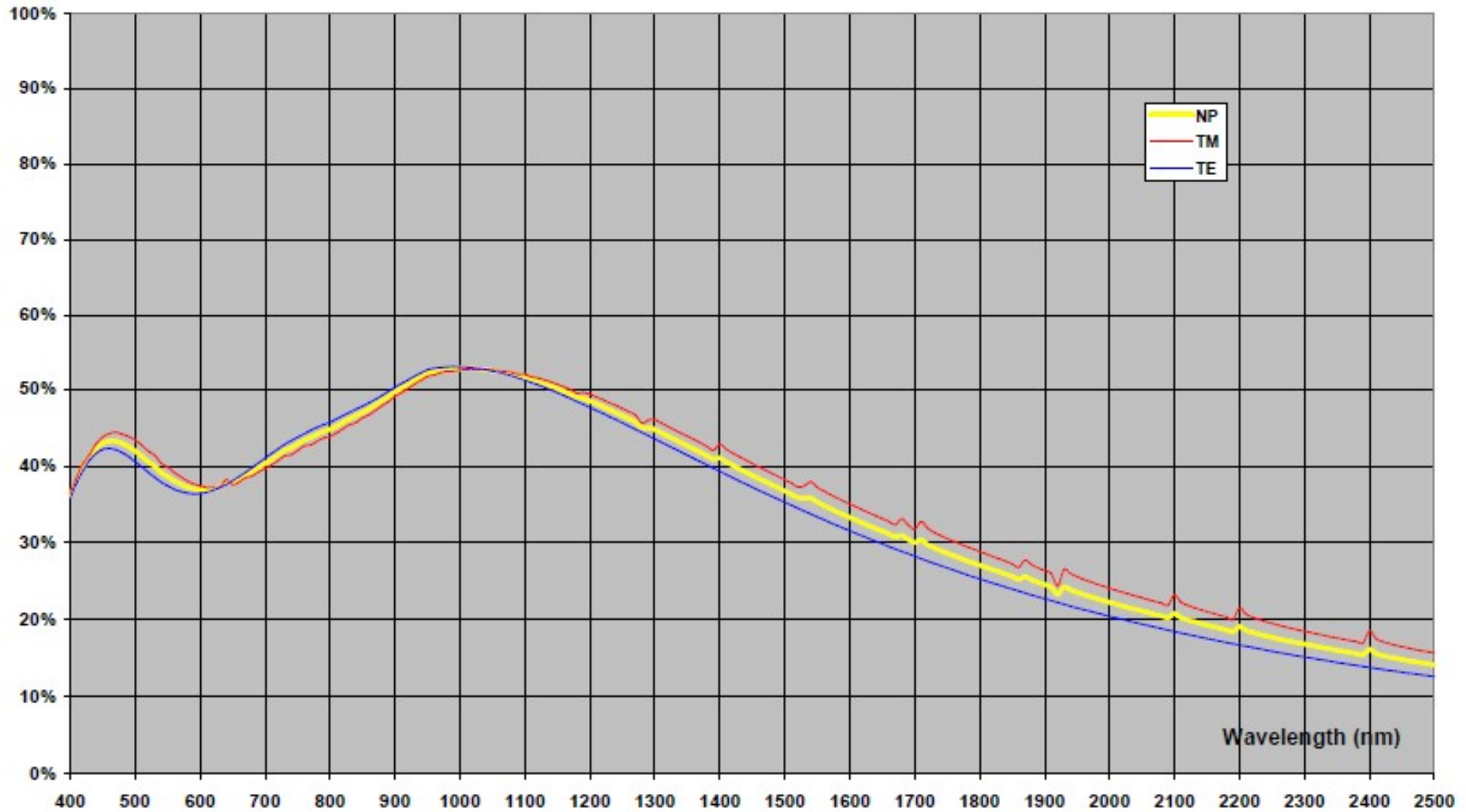
After the success of JIRAM, we developed a more challenging grating, with a low blaze angle, low groove density and very large spectral range (Mercury surface observation).

- **Low blazed angle ruled gratings (ruling machine) ;**
- **Manufactured in 2011 – 2012;**
- Low groove density ; **62gr/mm**
- Spectral range : 400 – 2000nm ;
- Space flight environmental conditions qualified.



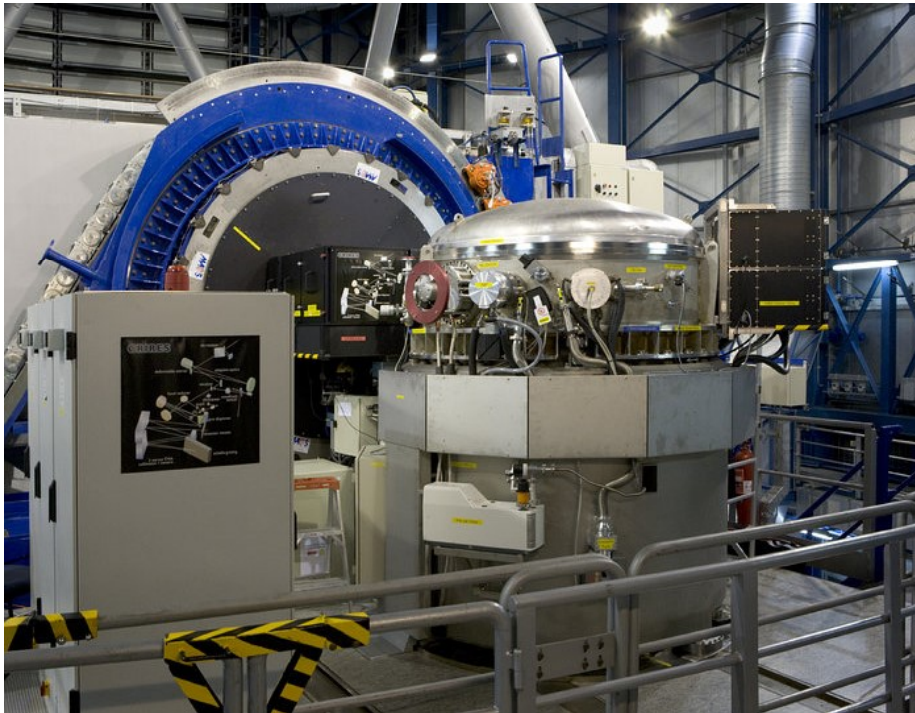
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ESA-JAXA Bepi Colombo Mercury mission – VIHI instrument (2011 - 2012)



CRIRES+ cross-dispersers

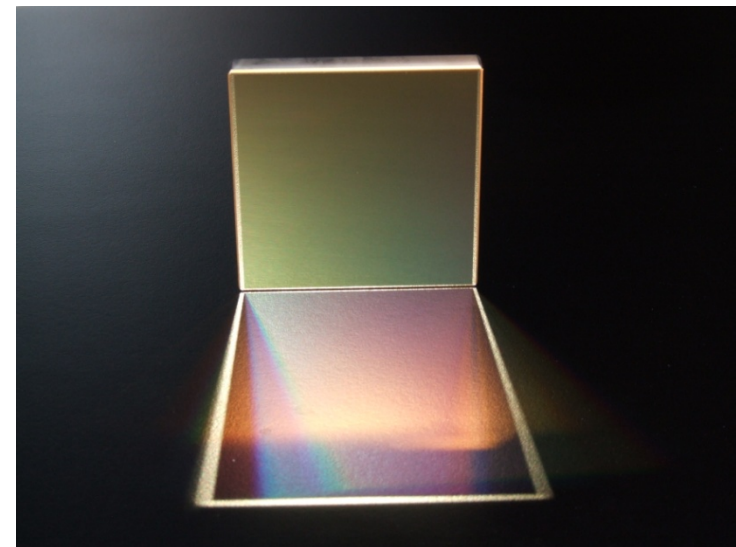
Cryogenic high-resolution infrared echelle spectrograph



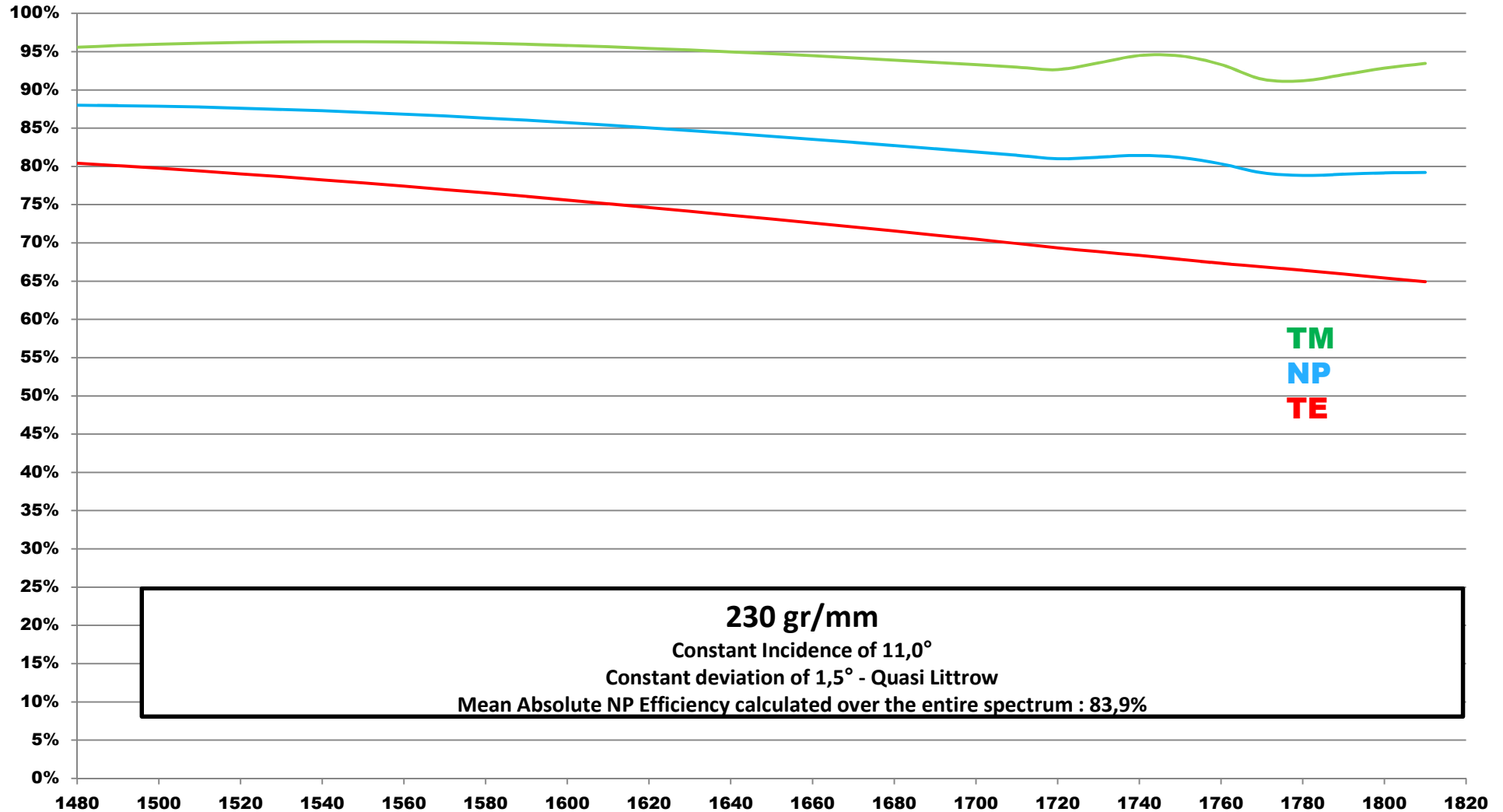
Credit: ESO

3 ruled plane gold-coated gratings

230gr / 360gr / 480gr/mm



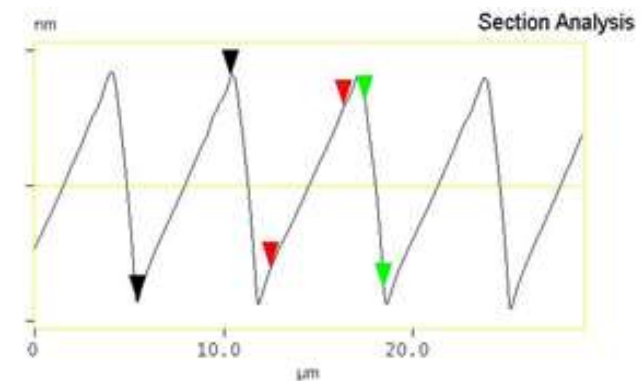
CRIRES+ Cross Dispersers



Transmission replica grating from ruled reflection master grating

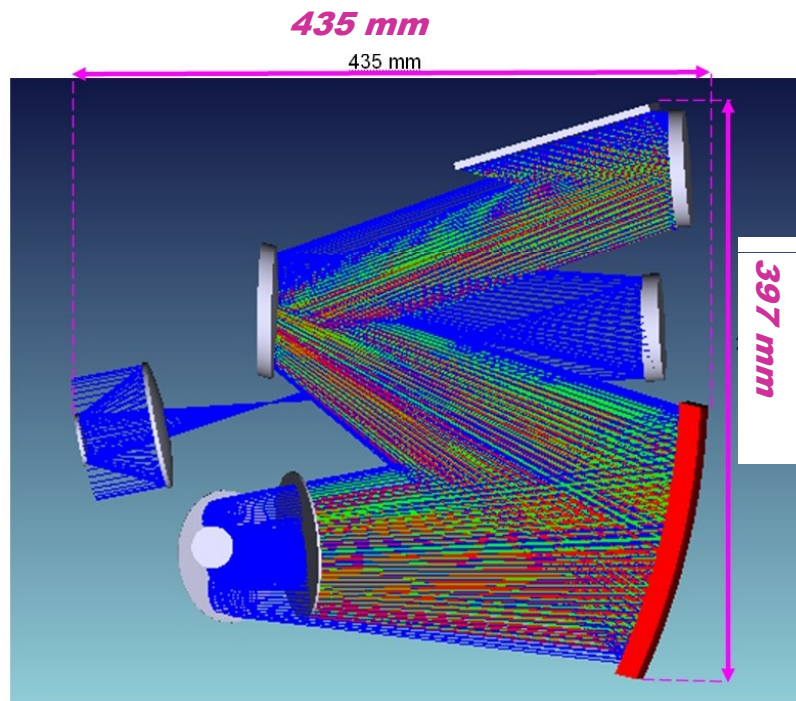
For low groove density where a VPHG design doesn't work, the perfect solution is to use a transmission replica ruled grating :

- **Transmission replica ruled grating**
- **surface photoresist profile ;**
- Spectral range : $1\mu\text{m}$;
- Groove density : $150\text{gr}/\text{mm}$;
- Very accurate groove profile ;
- Dimensions : $56 \times 126 \times 6\text{mm}$;
- Efficiency similar to the master reflection grating ;
- Plane shape.

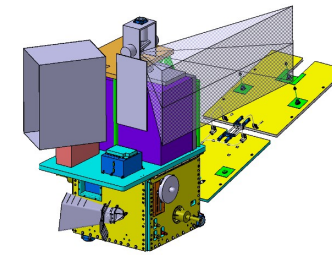


Echelle ruled gratings

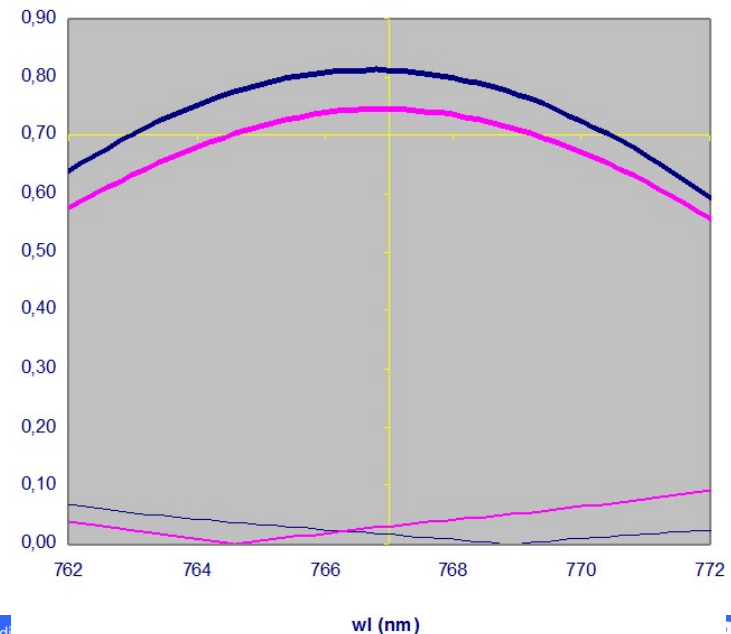
Development of Echelle gratings for compact NIR multi-bands space-flight spectrometers



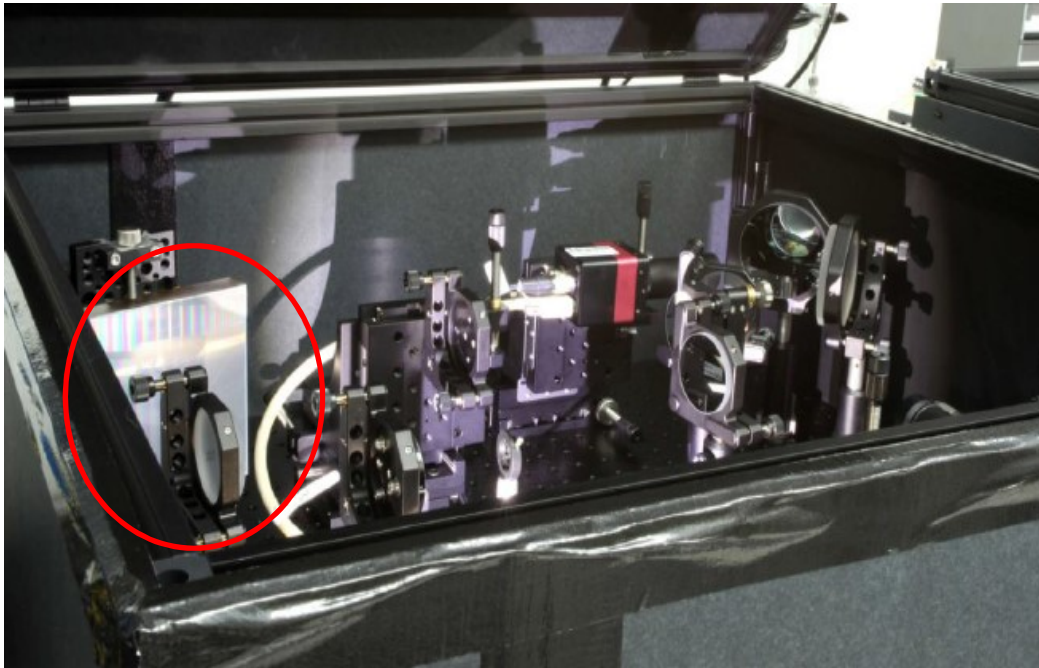
Patent CNES :
« *High performances compact echelle grating spectrometer with double pass telescope* »



B1



Echelle ruled gratings



Breadboard spectrometer prototype with HJY Echelle grating

- **Design and optimized by HJY R&D team to work in 15, 19, 40th orders : 3 spectral bands;**
- **Measurement in efficiency at 1.55 μ m ;**
- **Better stray light level than an equivalent standard Echelle grating.**

OUTLINE

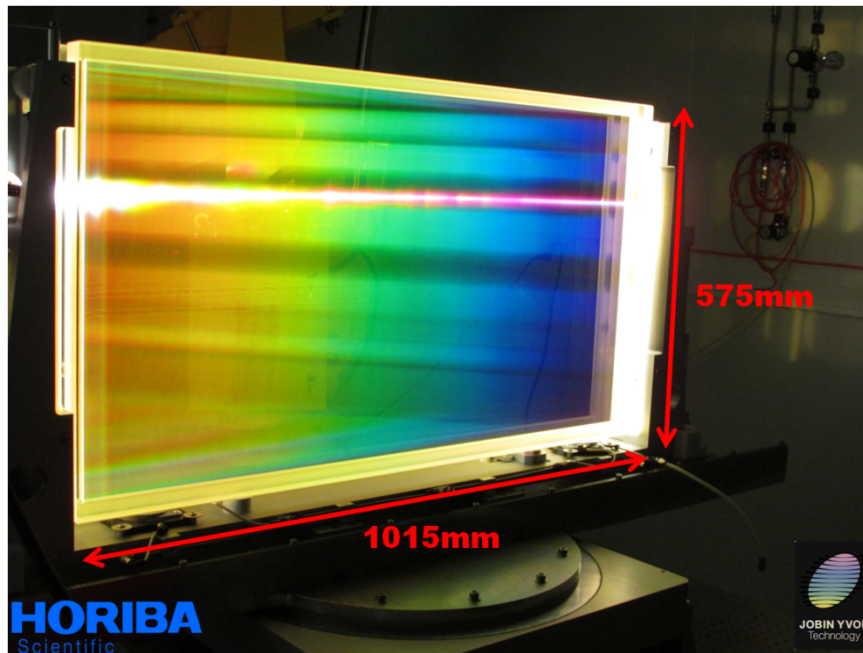
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Holographic gratings manufacturing process

Holography*



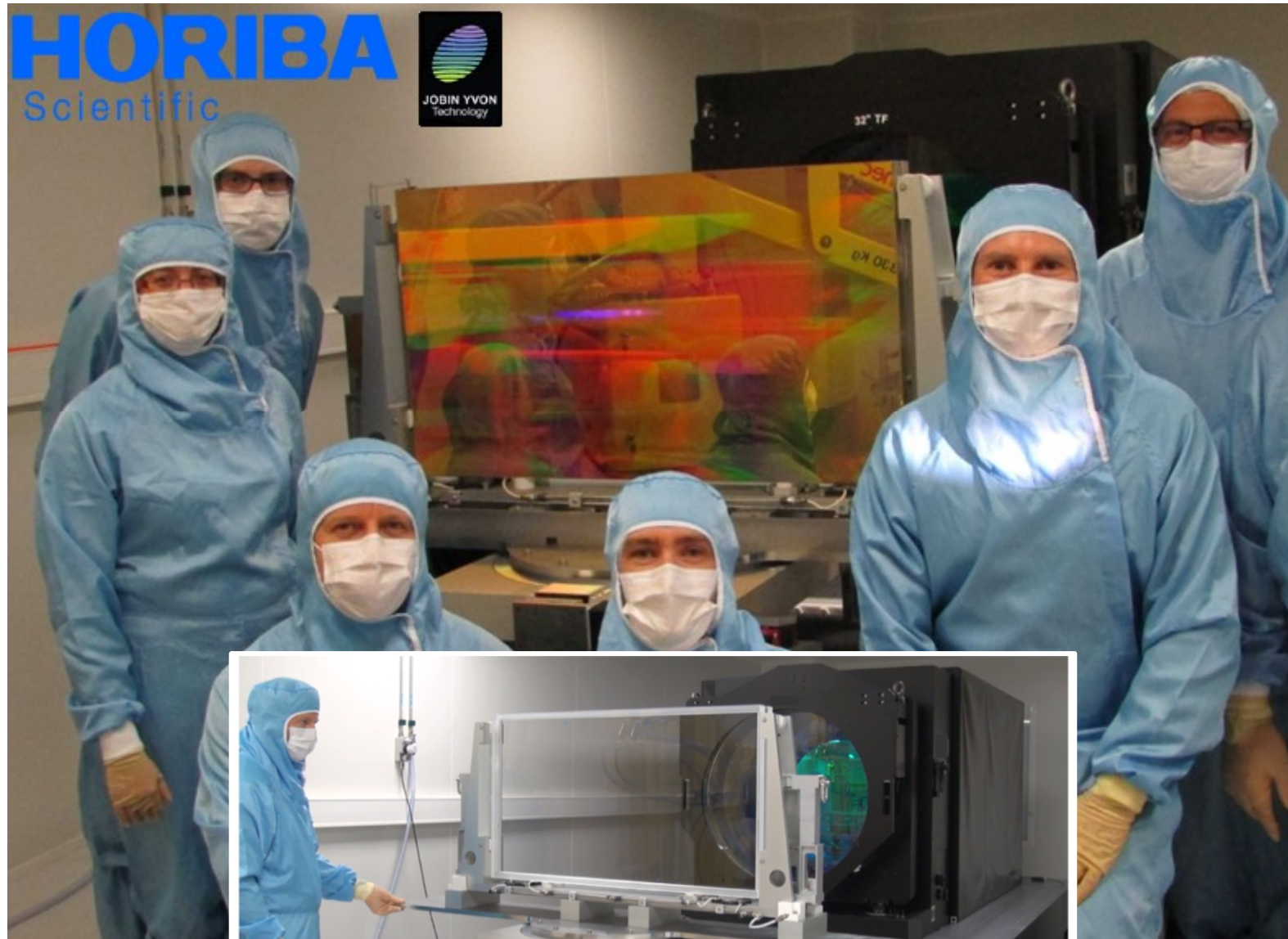
World Largest Holographic Grating

KEY FEATURES :

- Very high groove density up to **~6500gr/mm**
- Shape : plane, spherical, toroidal, free-form
- **Up to 1500mm** gratings capabilities
- Reflection or Transmission
- **High efficiency**
- **Low stray light**
- Replication possible (**TRL9**).

*** Jobin Yvon Patent : « Optical diffraction grating scanning device », Flamand J, Labeyrie A, Pieuchard G, 1970, US 3721487 A.**

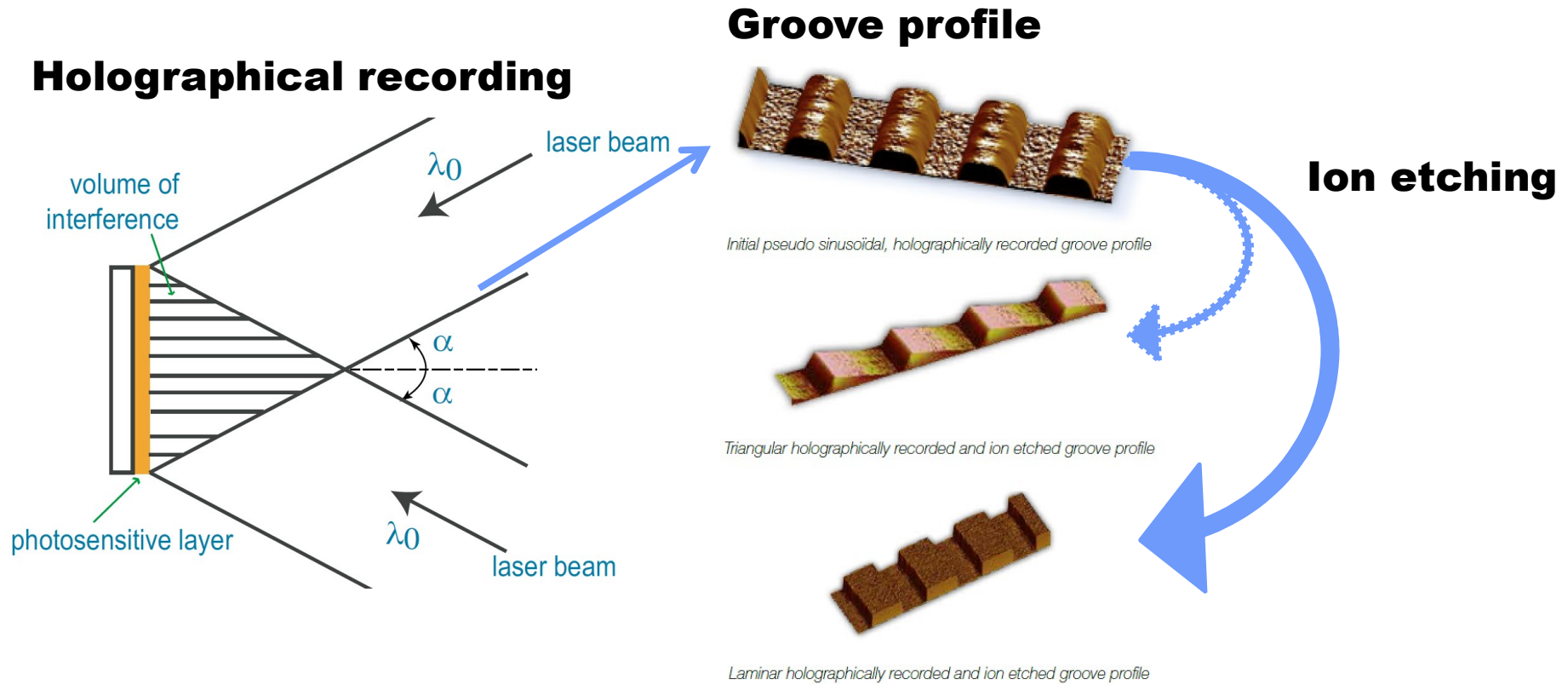
New meter size gratings facilities



HORIBA
Scientific



FSE grating process



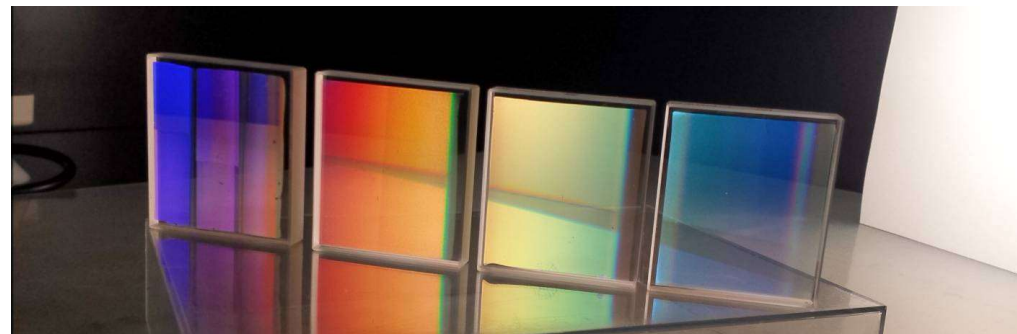
Fused Silica Etched (FSE) Transmission GRATINGS

FSE: a VPH alternativ

- **FSE gratings can have the same high efficiency + low polarization dependance as the VPHG gratings.**

AND :

- **More robust technology : gelatin free / no glass plates sandwich**
- **Better wavefront with thinner substrate**
- **Less sensitivity to the angle of incidence**



Please consult us to check feasibility

FSE grating type for laser market

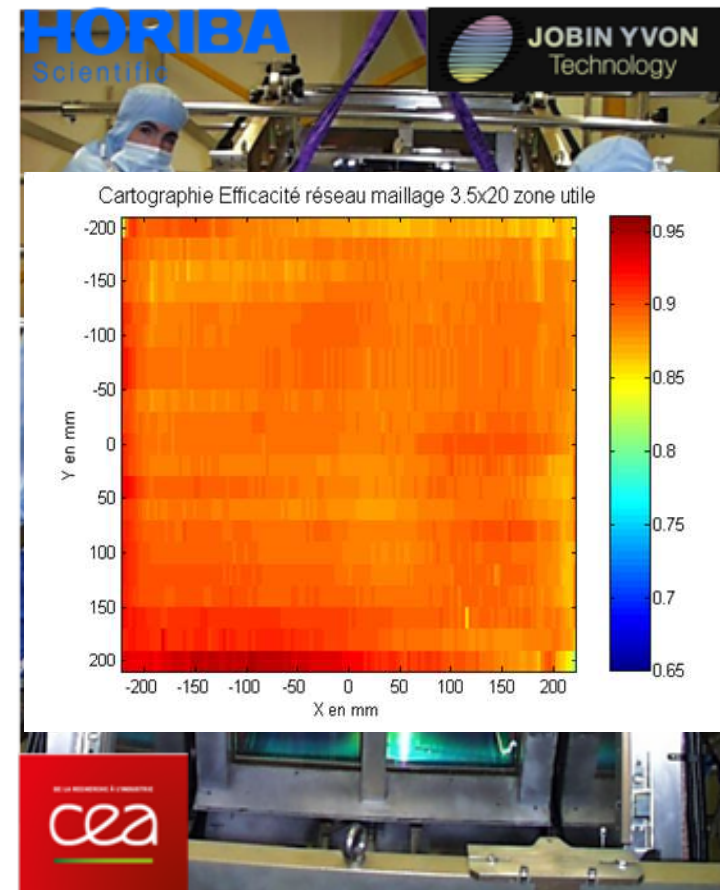
HJY manufactured since 1997 large size FSE transmission gratings for laser application

Laser Mega Joule (LMJ) Project Inertial Confinement Fusion

Transmission UV and NIR FSE gratings (800gr and 2400gr/mm) :

- Dimensions : 420x470mm,
- Efficiency : >90%.

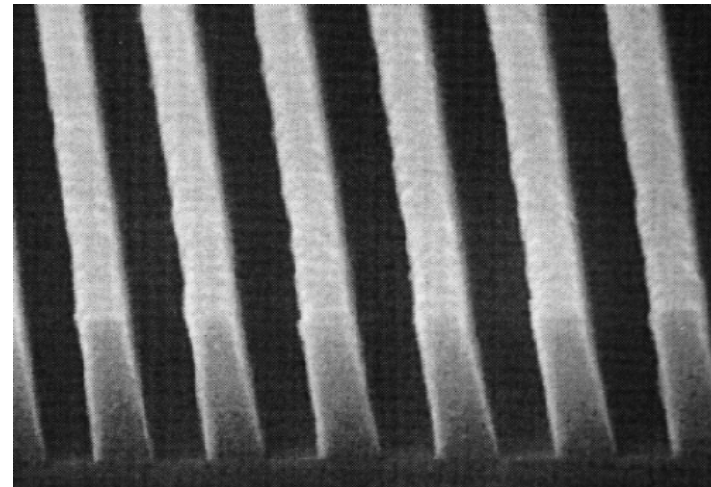
More than 330 gratings manufactured.



Transmission Fused Silica Etched (FSE) grating type

LIRIS (William Herschel Telescope) - EMIR instrument
(Gran Telescopio Canarias) : HJY has produced different type of Transmission FSE Gratings.

- **Transmission Holographic FSE grating (patented)** ;
- Spectral range : 0.9 μ m to 2.5 μ m ;
- Groove density : **from 486gr/mm to 1032gr/mm** ;
- Dimensions : D110mm/D135mm ;
- Plane shape ;
- Anti-Reflection coating ;
- Cryogenic environment tested.



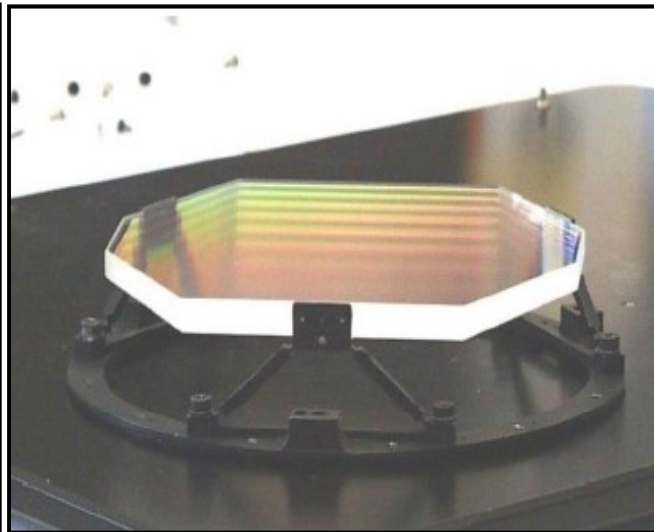
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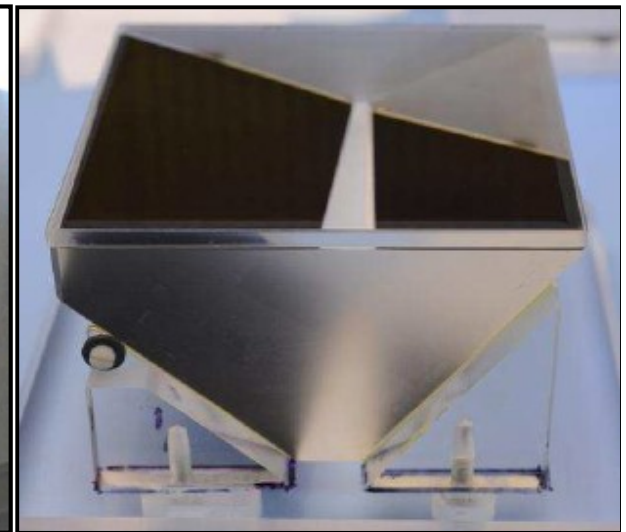
Transmission Fused Silica Etched (FSE) grating type GRISMS



800gr/mm, D135mm
transmission NIR
grating (EMIR)



75gr/mm, D130mm
transmission FUV-
NUV grism (GALEX)



3226gr/mm
120x120mm NIR
immersed grating

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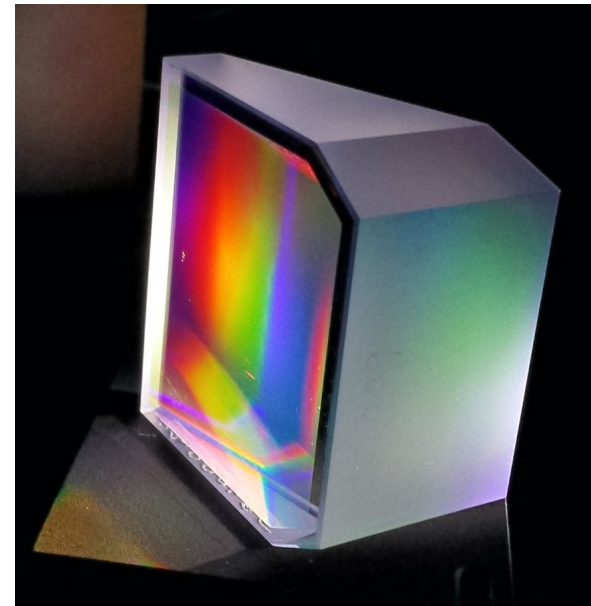


Transmission GRISM

- **Holographic recording+ion-etching inside fused silica**
- **AR coating on the opposite Grism face**
- **Cryogenic compatible, robust single piece of fused silica**

Space gratings (2017)

1500 gr/mm on [300-500nm] low polarization sensitivity

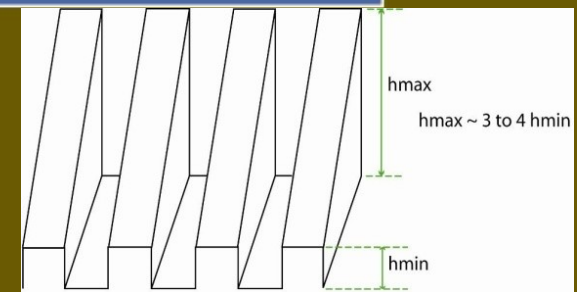
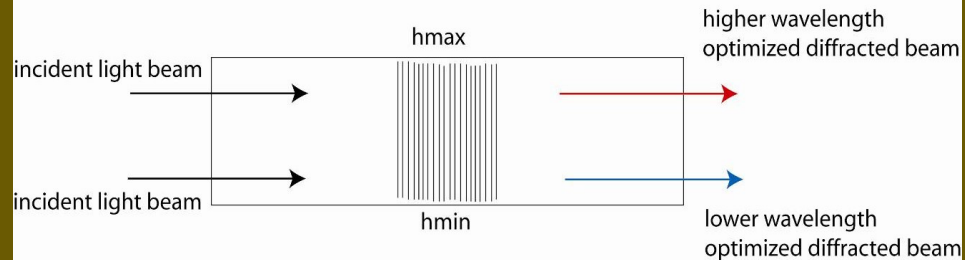
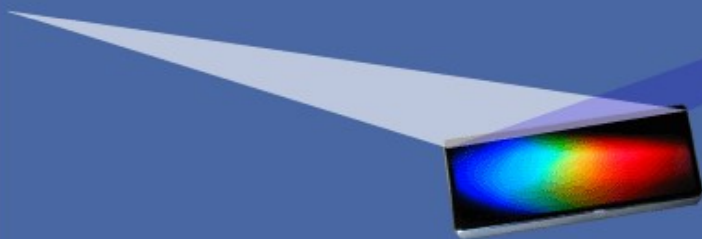
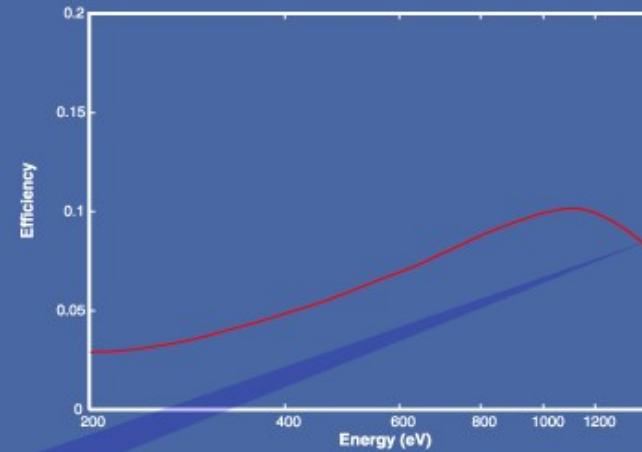


Variable Groove Depth (VGD) grating

A unique technology

VARIABLE GROOVE DEPTH GRATING The Tunable blaze grating

- Continuously Variable Groove Depth (VGD) grating
- Holographic Ion-Etched diffraction grating
- VLS or constant groove distribution
- One grating to replace several ones



Conclusion

- **HORIBA Jobin Yvon manufactures Space flight and astronomy gratings for >40 years.**
- **HJY continues to improve manufacturing process and metrology**
- **Many new topics in R&D: VPH, freeform, immersed...**
- **With the new Palaiseau R&D facility, we extend our production capability to reduce our delivery time.**



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Thank you very much for your attention.

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HORIBA

Omoshiro-okashiku
Joy and Fun

おもしろおかしく

眞峰


Thank you

감사합니다

Cảm ơn

Dziękuję

ありがとうございました

धन्यवाद

Grazie

Merci

谢谢

ขอบคุณครับ

நன்ற

Obrigado

Σας ευχαριστούμε

شكراً

Tack ska ni ha

Danke

Большое спасибо